Sounding Rocket Working Group
June 16, 2005

NASA Sounding Rocket Operations Contract (NSROC)

Goddard Space Flight Center

SRWG Agenda - NSROC

NSROC State of Affairs	Rob Maddox
NSROC Operations	Jay Scott
Ongoing Engineering Efforts	Dave Krause
Lynch 40.017 Failure Investigation & Recovery	
Mesospheric Sounding Rocket	
NSROC Engineering	Rick Weaver
Mechanical Engineering	Giovanni Rosanova
Clamp Release System	
Terrier Fin Modifications	
Electrical Engineering	Shelby Elborn
New transmitter	
Dual RMFT	
Command receiver	
New monitor box	
New power system control box	
GNC	Walter Costello
Boost Guidance System (S-19L) Upgrade	
Celestial ACS Design Overview	
Velocity Vector ACS Alignment Overview	
Conclusions	

Program Manager

Rob Maddox

NSROC Programmatic

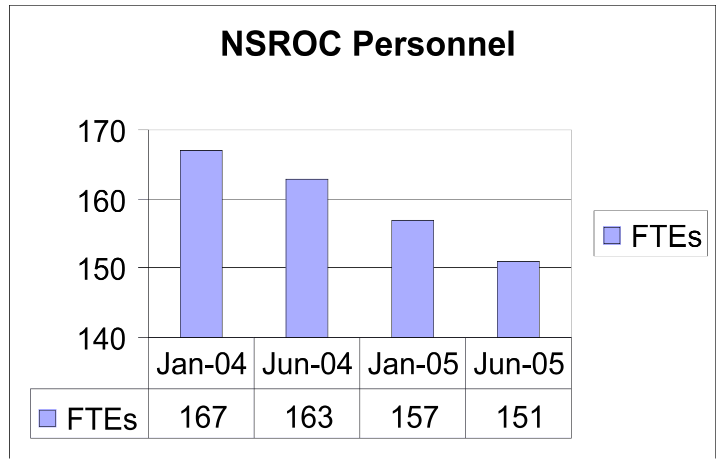
- Contract Status
  - Approaching middle of contract year 7
  - Very good PEB scores
- Subcontract Status
  - Aerojet -- minimized support
  - Bristol – Black Brant motor procurement pending investigation
    - Mgt. staff meeting with Bristol next week
  - DTI – Oriole motor procurement on hold
  - Saab – Significant effort underway for S-19L conversions

Programmatic

- Challenges
  - Implement new technology
    - Attitude Control Systems
    - New vehicle configurations
    - Black Brant Mk 1 failure
  - Complex Missions (Methods outside experience envelope)
    - Earle, Craven, Lessard, Chakrabarti, Technology Demo Flights
  - Budget
    - Balancing staff, procurements, reimbursable workload, to a dynamic budget
    - NSROC under budget for FY05 but Black Brant rocket motor procurement will carry over to FY06
  - Schedule

Programmatic

- Staffing
  - 151 FTEs
    - Down 6 FTEs since last SRWG
  - Reimbursable Offsets for Contract Year 6 = 15 FTEs



Programmatic

- New Business Opportunities
  - Navy ARAV exercises (Sept, Feb, June)
  - Air Force/MIT-LL Airborne Laser “MARTI”
  - Air Force Airborne Laser “Terrier Lynx Vehicle (TLV)”
  - MDA Terrier Improved Orion Tracking Targets
  - NSWC (OSD) Advanced Range Telemetry X-Band sounding rocket
  - DARPA Scramjet
  - ATK Elkton “ASAS demonstration”

NSROC Outreach

- Virginia Tech mission
  - Successfully launched May 17
  - Over 30 VT students participated in the project
- NSROC Co-op and Intern Program
  - Spring 2005 – 5 Co-ops
  - Summer 2005 – 4 Co-ops & 4 interns
  - Fall 2005 – 2 Co-ops

Operations Manager

Jay Scott

NSROC Operations

- Risk tables in review documents
- Started mission de-brief reviews
- Additional training continuous

NSROC Operations
Response to Jan 05 Finding

- User Access to NSROC documents
  - via FTP site
  - Directory structure
    - Completed Missions

      12.049 Ulwick

      12.050 Winstead

      12.051 Lynch

      ⋮

    - Current Missions

      12.055 Krause

      12.058 Costello

      12.059 Costello

      ⋮

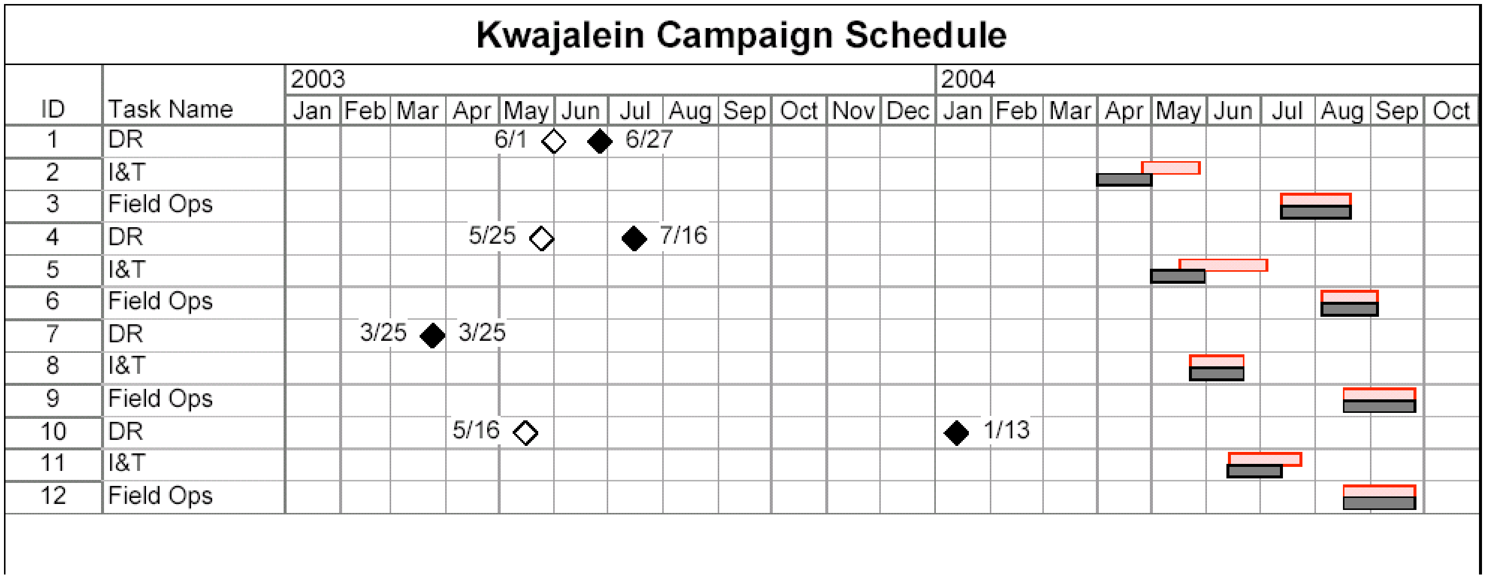
Mission Documentation

Folder Name	Folder Name	File Name	Comments
12.049 Ulwick	2MIC	12.049 MIC Notice.pdf	Notice of meeting date from SRPO
		12.049 MIC Science Package.pdf	Mission requirements from PI.
		12.049 MIC Memo.pdf	Record of MIC from SRPO.
	3RDM	12.049 RDM Notice.pdf	Notice of meeting date from NSROC
		12.049 RDMM.pdf	Record of RDM from MM.
		12.049 RDM Evaluation.pdf	Meeting and documentation evaluation from SRPO.
		12.049 Task Order.pdf	Task Order from SRPO
	4DR	12.049 DR Notice.pdf	Notice of meeting date from NSROC
		12.049 DRM.pdf	Includes memo from eng. with action items. Meeting documentation package is attachment
		12.049 DRAI Closeout memo.pdf	Includes memo from eng. stating AI responses have been reviewed and approved. Actual responses from payload team with supporting documentation is attached.
		12.049 DR Evaluation.pdf	Meeting and documentation evaluation from SRPO.
	5MRR	12.049 MRR Notice.pdf	Notice of meeting date from NSROC
		12.049 MRRM.pdf	Includes memo from eng. with action items. Meeting documentation package is attachment
		12.049 MRRAI Closeout memo.pdf	Includes memo from eng. stating AI responses have been reviewed and approved. Actual responses from payload team with supporting documentation is attached.
		12.049 ATL.pdf	Authorization to Launch memo from SRPO
		12.049 MRR Evaluation.pdf	Meeting and documentation evaluation from SRPO.
	6MCR	12.049 PI Results.pdf	Letter from PI to SRPO stating assessment of mission outcome.
		12.049 TMCR.pdf	Complete Technical Mission Closeout Report from MM.

NSROC Operations

- Sounding Rocket Program Handbook
  - Revised June 2005
  - Can be accessed at http://www.nsroc.com
    - Click Enter button
    - Select SRP Handbook from left menu

NSROC Operations
Scheduling

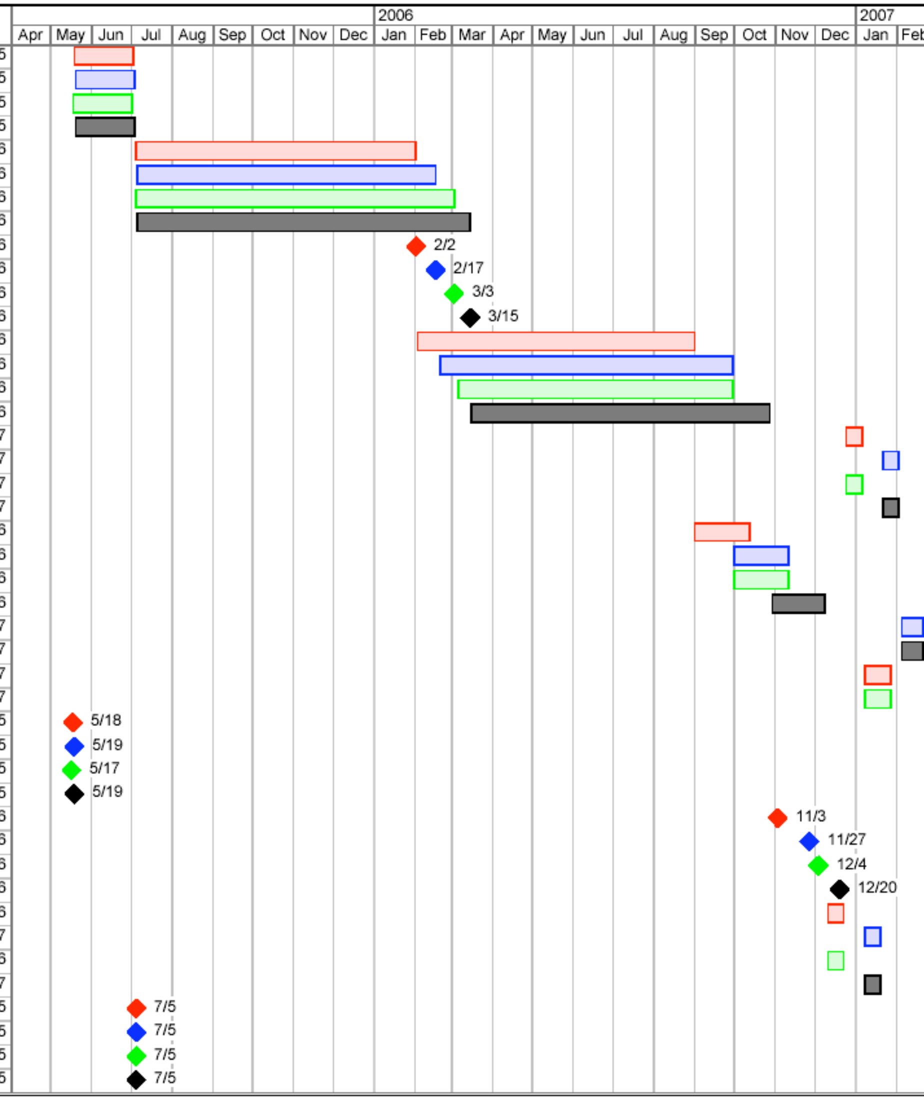


- DR's slipped
- Integrations slipped

Scheduling

Poker '07 Nominal Schedule

ID	Task Name	Duration	Start	Finish
2	Define Requirements	45 edays	5/18/05	7/2/05
13	Define Requirements	45 edays	5/19/05	7/3/05
24	Define Requirements	45 edays	5/17/05	7/1/05
35	Define Requirements	45 edays	5/19/05	7/3/05
4	Design	152 days	7/5/05	2/1/06
15	Design	162 days	7/6/05	2/16/06
26	Design	173 days	7/5/05	3/2/06
37	Design	9 mons	7/6/05	3/14/06
5	DR	1 day	2/2/06	2/2/06
16	DR	1 day	2/17/06	2/17/06
27	DR	1 day	3/3/06	3/3/06
38	DR	1 day	3/15/06	3/15/06
6	Fabrication/assem/elect chk	7.5 mons	2/3/06	8/31/06
17	Fabrication/assem/elect chk	8 mons	2/20/06	9/29/06
28	Fabrication/assem/elect chk	7.5 mons	3/6/06	9/29/06
39	Fabrication/assem/elect chk	162 days	3/16/06	10/27/06
10	Field Ops	2 wks	12/25/06	1/5/07
21	Field Ops	2 wks	1/22/07	2/2/07
32	Field Ops	2 wks	12/25/06	1/5/07
43	Field Ops	2 wks	1/22/07	2/2/07
7	Integration	6 wks	9/1/06	10/12/06
18	Integration	6 wks	10/1/06	11/10/06
29	Integration	6 wks	10/1/06	11/10/06
40	Integration	6 wks	10/30/06	12/8/06
22	launch window CHARM	16 edays	2/5/07	2/21/07
44	launch window HEX2	16 edays	2/5/07	2/21/07
11	launch window JOULE2	20 edays	1/8/07	1/28/07
33	launch window ROPA	20 edays	1/8/07	1/28/07
1	MIC	1 day	5/18/05	5/18/05
12	MIC	1 day	5/19/05	5/19/05
23	MIC	1 day	5/17/05	5/17/05
34	MIC	1 day	5/19/05	5/19/05
8	MRR	1 day	11/3/06	11/3/06
19	MRR	1 day	11/27/06	11/27/06
30	MRR	1 day	12/4/06	12/4/06
41	MRR	1 day	12/20/06	12/20/06
9	pack/ship	2 wks	12/11/06	12/22/06
20	pack/ship	2 wks	1/8/07	1/19/07
31	pack/ship	2 wks	12/11/06	12/22/06
42	pack/ship	2 wks	1/8/07	1/19/07
3	RDM	1 day	7/5/05	7/5/05
14	RDM	1 day	7/5/05	7/5/05
25	RDM	1 day	7/5/05	7/5/05
36	RDM	1 day	7/5/05	7/5/05



6/14/05

Chief Engineer

Dave Krause

40.017 Failure Investigation

- NASA chartered Mishap Investigation Board (MIB)
  - Chair: Steve Nelson
  - Members: P. Ward, D. Kotsifakis, T. Moskios, T. Potterton
  - Investigation/Report in Process
- Mission Failure Cause
  - No 3^{rd} Stage Ignition – Black Brant Mk 1 Rocket Motor
  - Igniter flash seen coming out of Mk 1 nozzle on All-sky camera
- Motor Heritage
  - 2^{nd} flight of the Mk 1 Motor
  - Demo flight in 1998 on CSA ACTIVE mission - successful
    - Terrier Mk 12/Brant Mk 1
  - 1^{st} NASA Flight
    - BBXII
    - 3^{rd} stage ignition altitude – 37kft, 3 psi

BB Mk 1 Igniter Redesign

- Face-to-face with Bristol next Tuesday, June 21.

- 2 Major questions loom
  - What specifically caused the non-ignition on 40.017?
  - What is the plan to fix the igniter?

- Other questions
  - Ignition pressure spike
  - Strength and margins on steel
  - Ignitibility of HTPB propellant

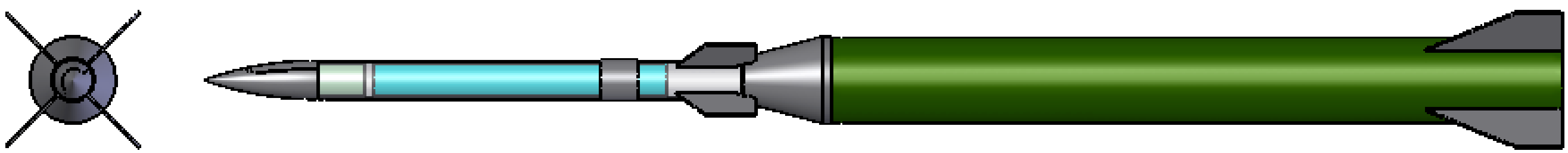
- Critical NSRP Design Criteria
  - Redesign with high reliability, heritage and robustness in mind
  - Compile a test program that will flight qualify to >40k ft altitude

Mesospheric Sounder Vehicle

Vehicle/Mission Requirements

- _ Payload passes through science region of interest, 85-92 km
- _ Maximum of 20 deg _ cone angle through 85-93 km
- _ Attitude knowledge through the science region
- _ Adequate volume to package science instruments and payload avionics
- _ Releasable nosecone to expose science payload.
- _ GPS for tracking purposes and trajectory reconstruction
- _ Allows for temporal measurements
- _ Low cost
- _ Rapid turnaround

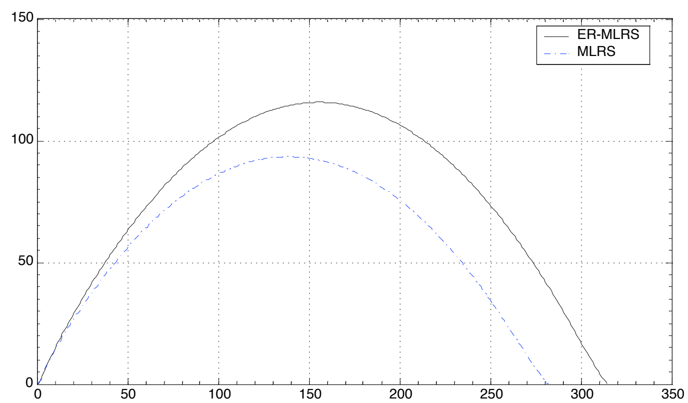
Meso Vehicle Configuration - Mesquito

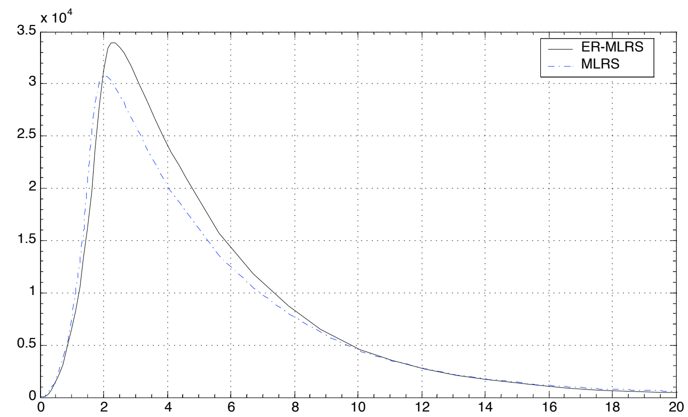


- 2nd stage non-propulsive Dart
  - 4 inch diameter body
  - Electronics Section (BLUE)
    - Encoder, Transmitter, Power, Wrap Antenna, GPS, pyro circuit, mag, accels,
  - EXP Section (GREEN)
    - Defined Interface volume and mass
    - ~3.4”ø, ~6” long
  - Nosecone,
    - Deployable
    - single pyro event
  - Drag Separation Joint (tapered aft end)

- MLRS Booster Motor
  - Solid Propellant Motor
  - ~2 sec burn time, ~35,000 lbf thrust
  - 9 inch diameter, 77.6 inch long
  - Steel case motor
  - New hardware
    - Forward Interstage
    - Spring loaded fwd launch lug
    - Fixed aft lug
    - New fins
      - plate stock
      - high temp steel

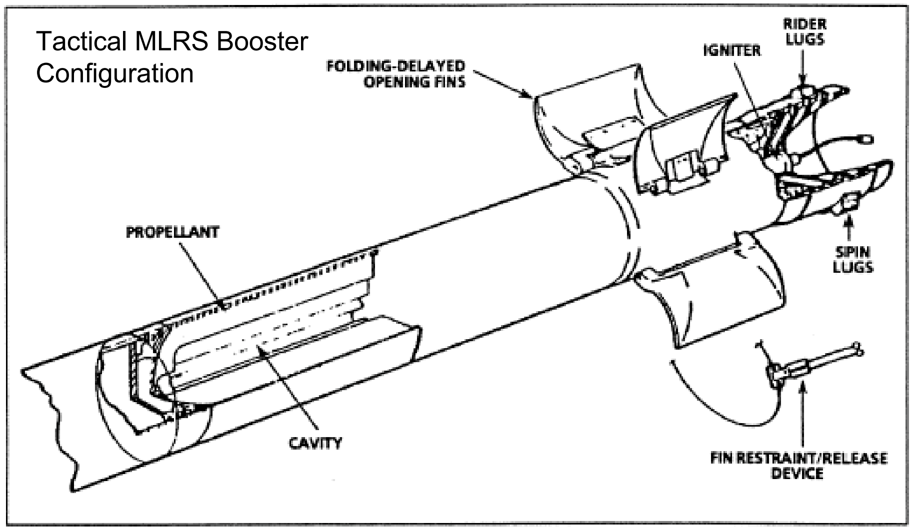
Mesospheric Sounder Performance w/ MLRS

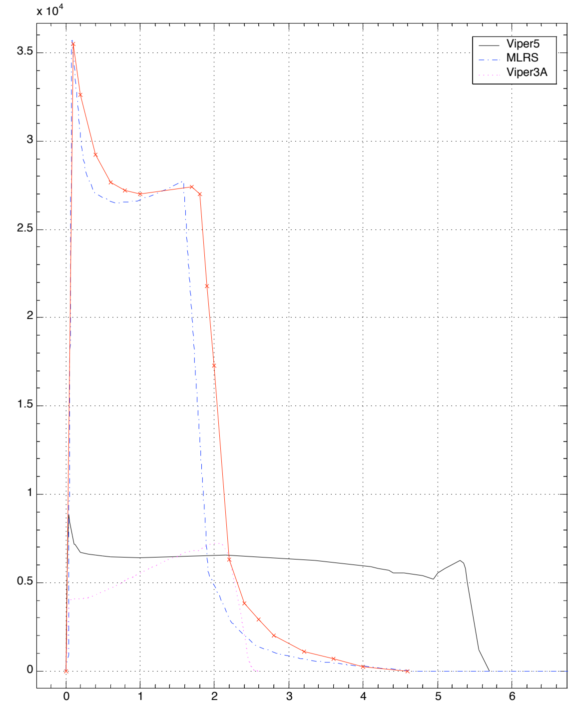




MLRS Motor Data

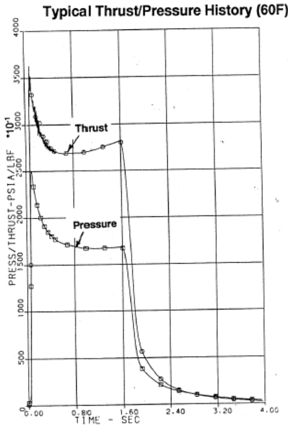
Tactical MLRS Booster Configuration





MLRS Rocket Motor

Typical Thrust/Pressure History (60F)

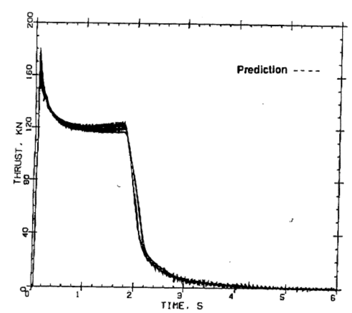


Ballistic and Physical Characteristics (60F)

Burn Time, s	1.624
Maximum Thrust, lbf	37567
Maximum Pressure, psia	2584
Average Thrust, lbf	28084
Average Pressure, psia	1721
Delivered Specific Impulse, s	234.8
Total Impulse, lbf-sec	50724
Propellant Weight, lbm	216.0
Total Weight, lbm	325.0
Mass Fraction	.665
Total Length, in	77.6
Outer Diameter, in	8.96
Operating Temp Limits, F	-26 to +140
Propellant	Arcadene 360B

SEQUA *ER MLRS Booster Configuration and Capability* ARC

Typical Thrust History (60F)

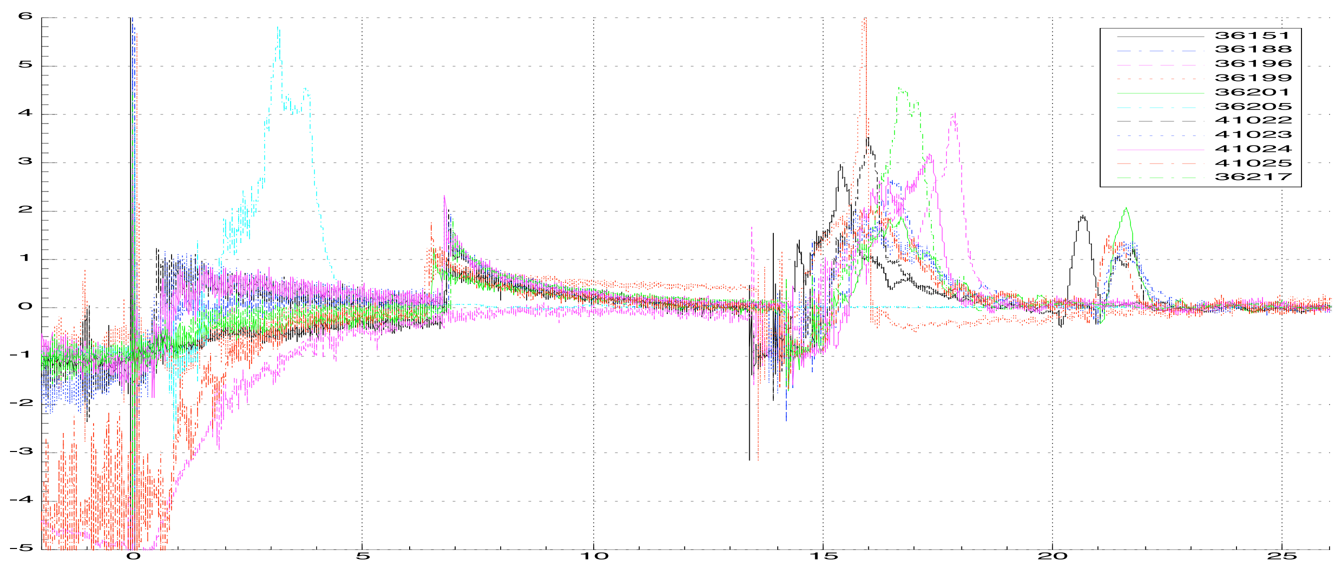


Ballistic and Physical Characteristics (60F)

Burn Time, s	1.755
Maximum Thrust, lbf	35162
Maximum Pressure, psia	2527
Average Thrust, lbf	27585
Average Pressure, psia	1741
Delivered Specific Impulse, s	234.5
Total Impulse, lbf-sec	58235
Propellant Weight, lbm	248.2
Total Weight, lbm	370.7
Mass Fraction	.670
Total Length, in	86.2
Outer Diameter, in	8.96
Operating Temp Limits, F	-26 to +140
Propellant	Arcadene 360F

Recovery Systems

- Increased post flight data evaluations since the Golub/36.199 parachute failure causing steep learning curve
- ~50% of WSMR recovery systems note ‘nominal’ long-axis acceleration response during staging sequence
- Appears that payload dynamics are very ‘dynamic’; random tumbling, high roll rates, spin up, spin down, spin reversal
- 12.058 mission will incorporate a camera and self-contained recorder



Engineering Manager

Rick Weaver

Staffing

Contract Staffing Level

GNC lost one engineer.
Mechanical lost one engineer.
Electrical lost two engineers.

One new hire in the GNC group (MSEE), Neil Shoemaker started June 13.

We are in the process of interviewing and extending offers for 2 ME's and 2 EE's.

Technical Staff supporting several concurrent missions.

The current launch operation schedule is better then previous 6 month report, and next 6 month looks as if the work load will remain constant.

Engineering Management

Engineering Manager (74 3/4)
Rick Weaver (OSC)

Admin. Assistant
Yvonne Nock (OSC) (1/2)

GNC Engineering (21 1/4)

Walt Costello- FP/ GNC Supervisor (OSC)
Denise Crippen - (RSS) Documentation Tech
Brian Tibbetts – Prin Eng (OSC)
Jeffrey Benton - GNC Eng. (OSC) Systems Eng. 1
Charles Kupelian – Systems Eng. 2
John Ozanne - Systems Eng. 3
Ron Kiefer - GNC Eng. (OSC)
Valerie Gsell – GNC Eng. (OSC)
David Jennings – GNC Eng (ARC)
Neil Shoemaker- GNC Eng. (OSC)
Gerald Doyon - GNC Eng. (OSC)
Pat McPhail – SCA Eng. Tech VI
David Lang - SCA Eng. Tech V

WSMR Engineering (7)

Carlos Martinez - GNC Eng. (OSC)
Jesus Martinez - GNC Eng. (OSC)
Chris Hoxworth– GNC Eng. (OSC)
Paul Harmon - GNC Eng. (OSC)
Stephen Bower – GNC Tech (ARC)
Bruce Howard - GNC Tech (OSC)
Becky Grzelachowski – SCA Secretary IV

Flight Performance

Mark Simko - FP Eng. (OSC)
David Kilcoyne – Systems Eng. 1
Michael Disbrow - FP Eng. (OSC)
D. Brent Edwards- Systems Eng. 1
Sylvia Onions (1/2) – SCA Eng. Tech V
Brian Holland - FP Computer Analyst
Dennis Melvin (3/4)-FP

Vehicle Systems Engineering (8)

Giovanni Rosanova - Supervisor (OSC) **(1/2)**
Jarret Morton –(OSC)
Sylvia Onions (1/2) – SCA Eng. Tech V
David Burkhead – EE2
Timothy Branch - ME (OSC)
Gerald Christeson - ME (OSC)
Paul Evans - VS Tech (OSC)
Rick Evavold - VS Tech (OSC)
Vacant

Electrical Engineering (20 1/4)

Shelby Elborn – Supervisor (OSC)
Yvonne Nock (1/2) – Admin. Asst (OSC)
Charles Lankford – Lead EE (OSC)
James Diehl – Comm. Systems Eng. 3
Charles Lewis - EE (OSC)
Eric Johnson - EE (OSC)
Thomas Malaby - EE (OSC)
Scott Hesh – EE 1
Matthew Vaughn – EE1
Chris Bradley – EE 1
John Gsell - EE (OSC)
Steven Orosz – EE 1
Scott Blake (3/4) – EE 2
Kenneth Starr - GNC Tech (OSC)
Vacant Vacant

Mechanical Engineering (1713/4)

Giovanni Rosanova - Supervisor (OSC) **(1/2)**
Susan Weidner – Admin. Asst (RSS)
Orville Fleming – Hardware Eng. 2
Ted Finne – Hardware Eng. 1
Matthew Peterson- ME (OSC)
Brian Creighton – ME (OSC)
Mark Hylbert – SCA Drafter IV
Richard Paschak - Drafter IV (ARC)
Ken Walthall – Drafter IV (OSC)
Vacant
Vacant

WSMR/PSL
5 FTEs
Note: not for personnel count

Environmental Test

Glen Maxfield – Test Eng. 1
Dan Hudson – SCA Eng. Tech V
Robert Marshall - SCA Eng. Tech VI
Michael Sharpe - SCA Eng. Tech V
Tom Russell – SCA Eng. Tech V

Staffing

New Vehicle Systems Group Definition of Duties

Structural Engineer

- Research, obtain and keep structural design data for all rocket motors, interstages, fins, launcher interfaces and other related hardware in the sounding rocket stable.
- Perform structural analysis of vehicle hardware for every mission and provide factors of safety to DR and MRR panels for review. This analysis shall be based on, at a minimum, flight loads and loads on the launcher.
- Perform structural testing as needed to verify analysis mentioned above.
- Design, analyze and test hardware for new vehicles. Do the same for new hardware on existing vehicles.
- Support design, analysis, test and survey of launchers as needed.
- Serve as Material Review Board representative for Vehicle related issues
- Primary representative at milestone/deliverable meetings.
- Identify, track, mitigate risks associated with vehicle hardware

Staffing

Recovery Systems Engineer

- Research, obtain and keep design data for all components and assemblies of recovery systems.
- Coordinate procurement of recovery system hardware. This shall include hardware manufactured in-house.
- Write necessary procedures and requirements documents that will guide vendors in building our systems properly.
- Coordinate inspection of recovery system hardware, including x-rays of packed chutes.
- Assign recovery systems for every mission (if required).
- Create process flow document for each recovery system variant.
- Using defined/published industry standard analysis tools, perform analysis of critical components during parachute staging for every mission. Provide factors of safety to DR and MRR panels for review.
- Review flight data from every recoverable mission to verify proper staging of parachutes. Provide report for mission closeout.
- Inspect all parachutes after every flight and provide report for mission closeout.
- Identify, track, mitigate risks associated with recovery systems

Staffing

Hardware Resource Planner

- Define vehicle hardware requirements for every mission via Firing Data Sheet process. Coordinate closely with Structural Engineer to ensure proper configuration.
- Work closely with Logistics Group to forecast vehicle hardware inventory needs.
- Act as main point of contact for vehicle hardware vendors.
- Provide vehicle hardware cost estimates to mission managers for every mission.
- Identify, track, mitigate risks associated with vehicle hardware planning & procurement

Ordnance Engineer

- Act as principal engineer for all NSROC standard ordnance systems (in-house CDI's and vendor provided ignition systems). Coordinate/approve any design changes to these standard systems.
- Coordinate development of FTS/TTS system new design and revisions to existing designs.
- Act as principal engineer for all vehicle assembly procedures. Develop new procedures and coordinate approval of revisions to existing procedures. Provide disposition/approval for deviation from procedures.
- Identify, track, mitigate risks associated with ordnance systems

Staffing

Propulsion Engineer

- Research, obtain, and keep all technical data on propulsive grain and performance characteristics for every motor in our stable. This shall include data on ignition train and exit nozzle/expansion cone characteristics.
- Review x-rays and all other propulsion-system-related inspection reports of every motor. Define new inspection requirements for all motors in order to have consistent policy across the stable.
- Perform analysis on performance of propulsion events for each mission. This shall include considerations for age of motor and propellant, altitude of ignition, spin rate, acceleration, etc. Provide report to DR and MRR panels for review.
- Analyze flight data after every mission to verify proper performance of motor. Work closely with Flight Performance Engineers to perform this evaluation.
- Consult with industry experts/propulsion houses on new materials/processes, aging/shelf life issues, verification and validation of propulsion systems.
- Identify, track, mitigate risks associated with propulsion systems

Field Support Personnel

- Receive and inspect standard vehicle support systems (ORSA, BB ign.) from Wallops.
- Perform WSMR field support for integration, testing and launch of these systems. This includes installation and testing of TTS hardware.
- Review flight data and provide report for mission closeout.

Electrical Engineering

Shelby Elborn

High Efficiency/Wide Bandwidth Transmitters

Issues

- PCM bit rates over 2 M Bits/Sec require use of 10 Watt S-Band transmitters.
- 10 Watt transmitters generate 75 Watts of heat
- Discrete frequency transmitters require stocking 10 different frequencies in each power rating.

Solution

- new high efficiency, wide bandwidth frequency agile units ordered
- 3 times the efficiency, 10 MHz frequency response, frequency programmable
- Smaller footprint and height, +10 to +36 Volt power supply input range.

Program Benefits

- Smaller/lighter battery packs, thinner/lighter TM deck plates, more compact TM systems
- Can be used with power supplies operating down to 10 Volts.
- Stock fewer transmitters, price will be ~50% less than stocked transmitters

Status

- Five each of 2 and 5 Watt units ordered.
- First article anticipated at WFF in November, 2005.

Dual RMFT

Issues

- CDI systems require 3-3” x 4” x 1” boxes for Event Timers and Support Modules.
- Our present Event Timers will not fit in the planned MLRS 4” diameter payload.

Solution

- Designed a dual Reprogrammable Multi Function Timer
- Housed in an existing 3” x 4” x 1” box.
- Boards can also be separated and housed in a 1.75” x 4” x 1” box.
- Design uses flight proven surface mount electronics used in GPS Event Module.

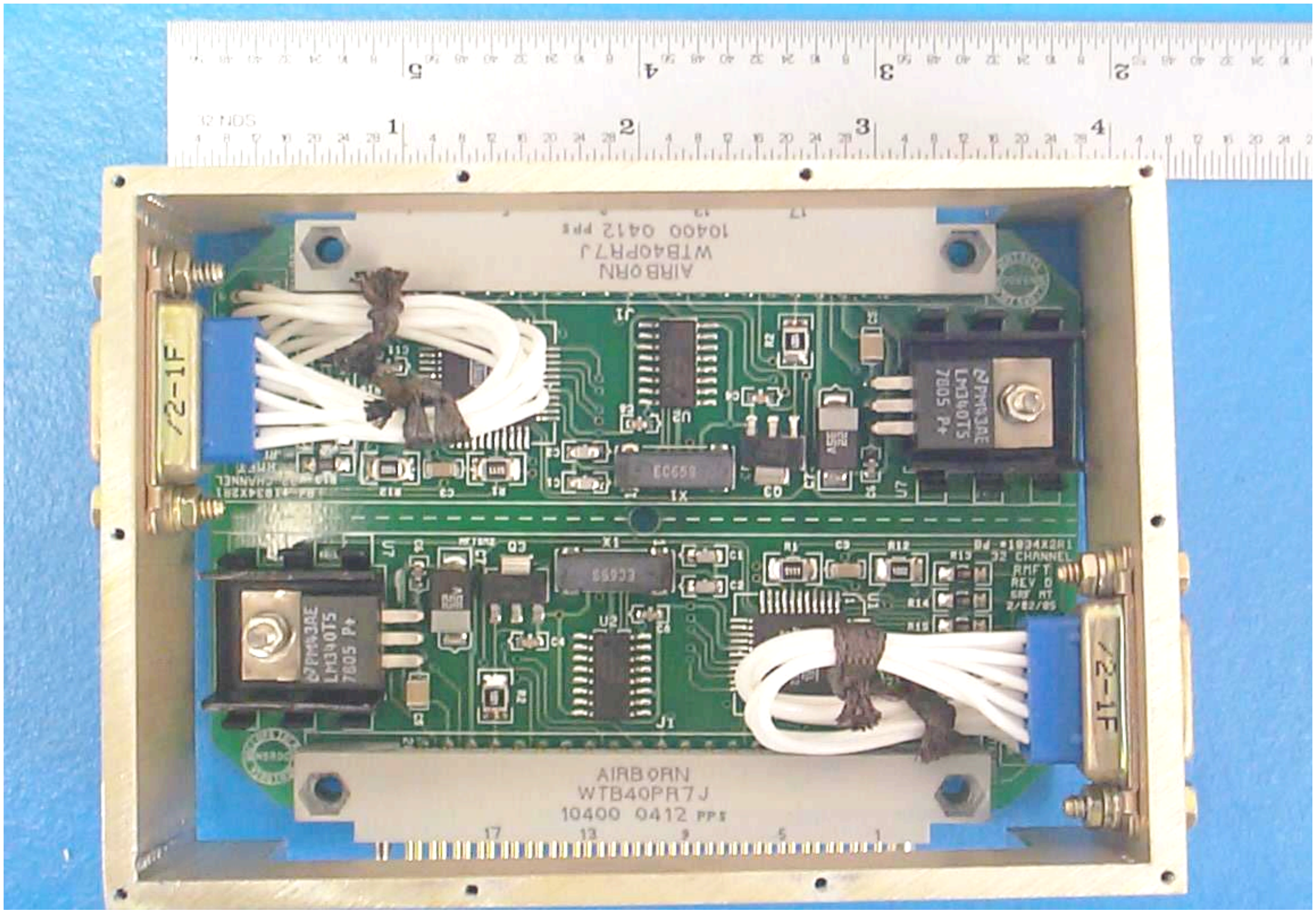
Program Benefits

- Single 3” x 4” x 1” box will be needed for the CDI system.
- Single RMFT configuration will permit use in the 4” diameter MLRS
- Connector selection allows adding 2 more event timer controlled outputs.

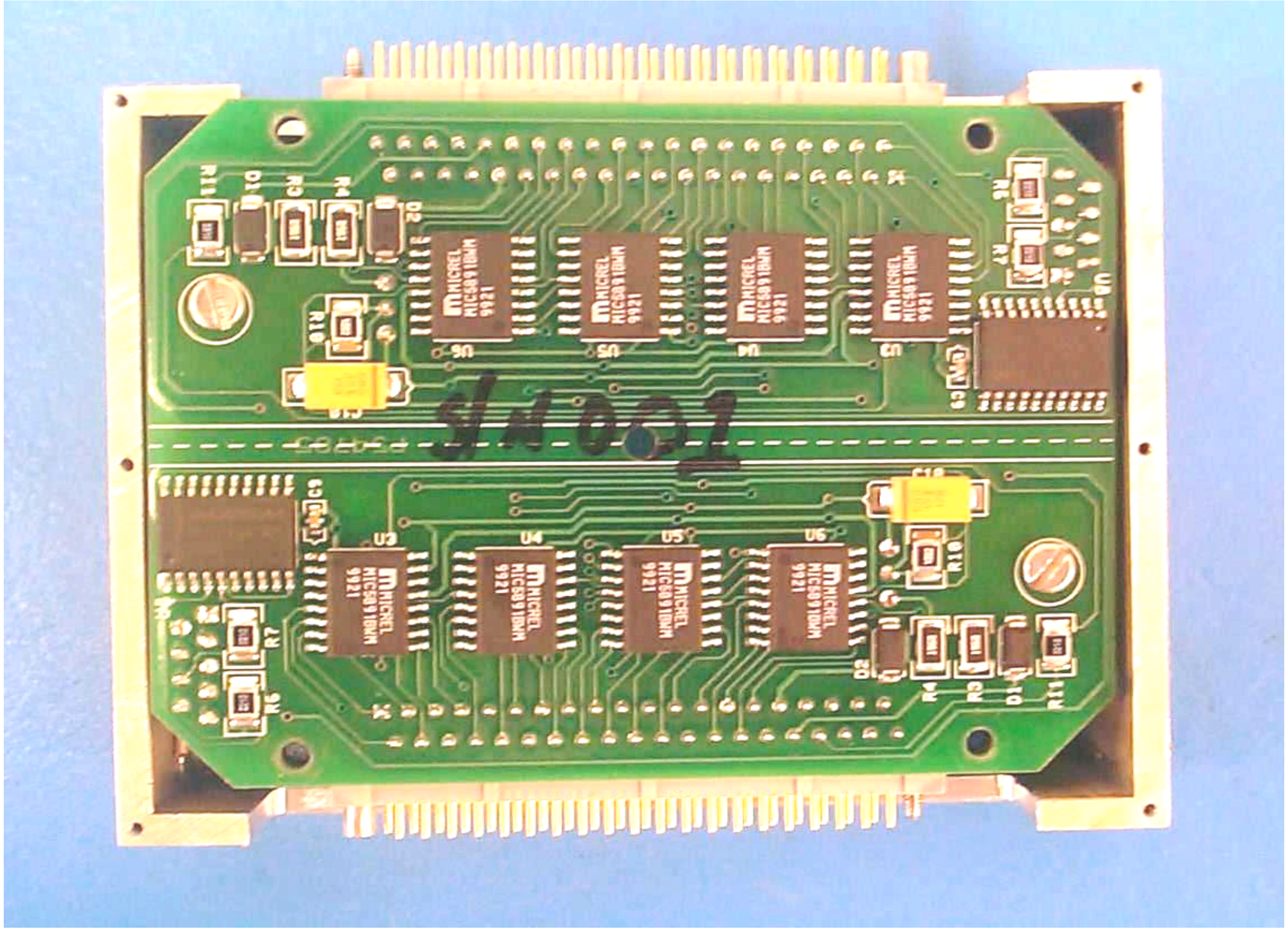
Status

- Electrical design completed
- First article electrically tested successfully.

Dual RMFT



Dual RMFT



Programmable Monitor Box

Issues

- Monitor circuits presently cannot be fabricated until the payload is designed.
- Multiple monitor boxes stocked

Solution

- Designed a standard programmable monitor board.
- Accommodates 32 inputs up to +/-32 Volts
- Outputs 32 channels analog, RS422 and synchronous serial digital data.
- Allows setting/adjusting parallel digital data trigger level outputs.

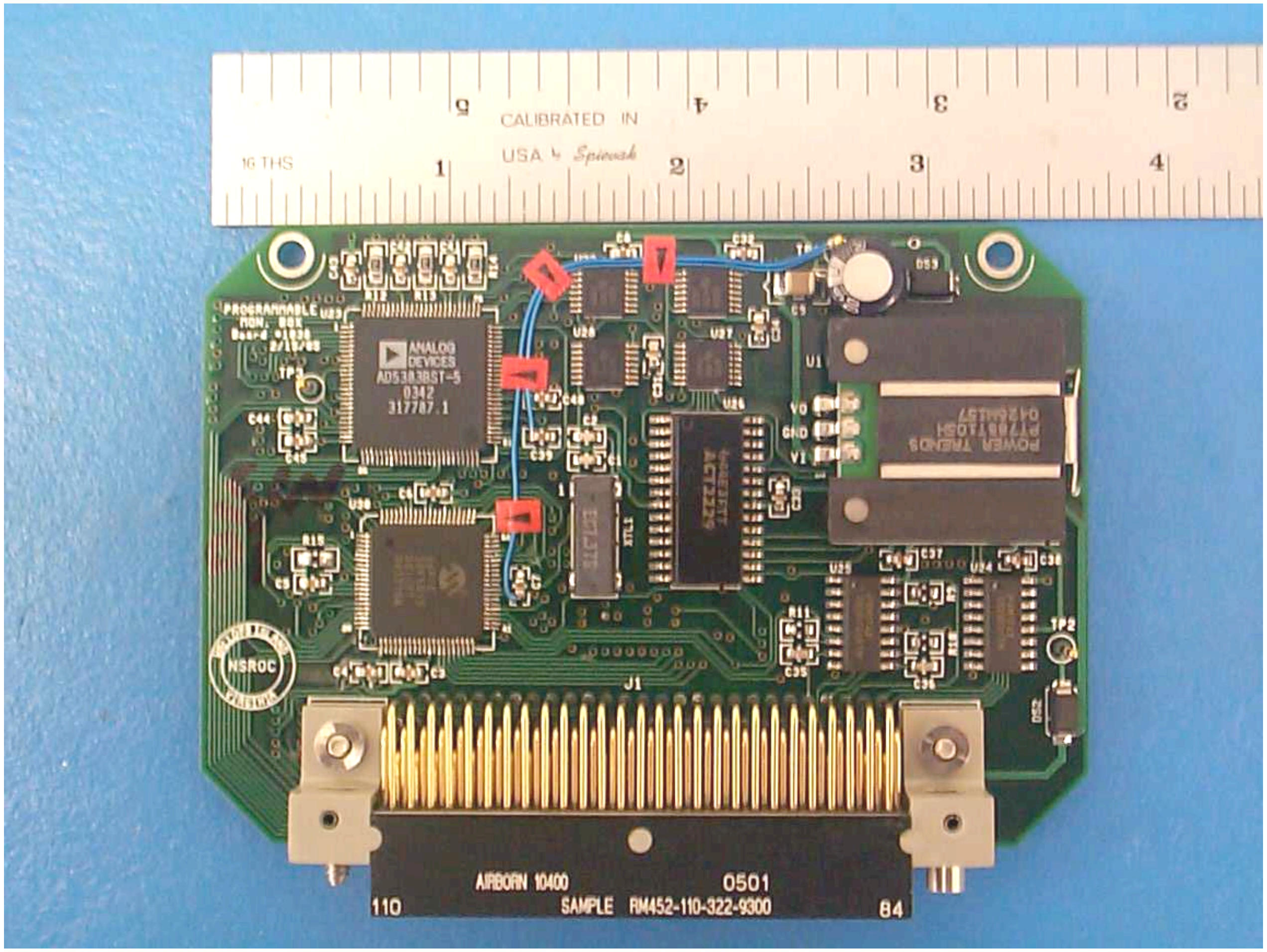
Program Benefits

- Replaces 7 existing monitor box circuit designs
- Allows complete assembly, verification, board potting prior to stocking
- Boards will be pulled from stock and programmed for mission needs.
- RS422 and synchronous serial digital data output will simplify payload wiring.

Status

- Electrical design completed.
- First article board has been assembled.
- Electrical qualification testing is set to begin mid June.

Programmable Monitor Box



Payload Power System

Issues

- Payload power systems are wired after the decks have been fabricated.
- No testing can be performed until the wiring has been completed.

Solution

- Designed a +28V power system in a box.
- Controlled using an RS232 interface from the GSE.
- Incorporates bus voltage monitoring and Internal/External status monitoring.

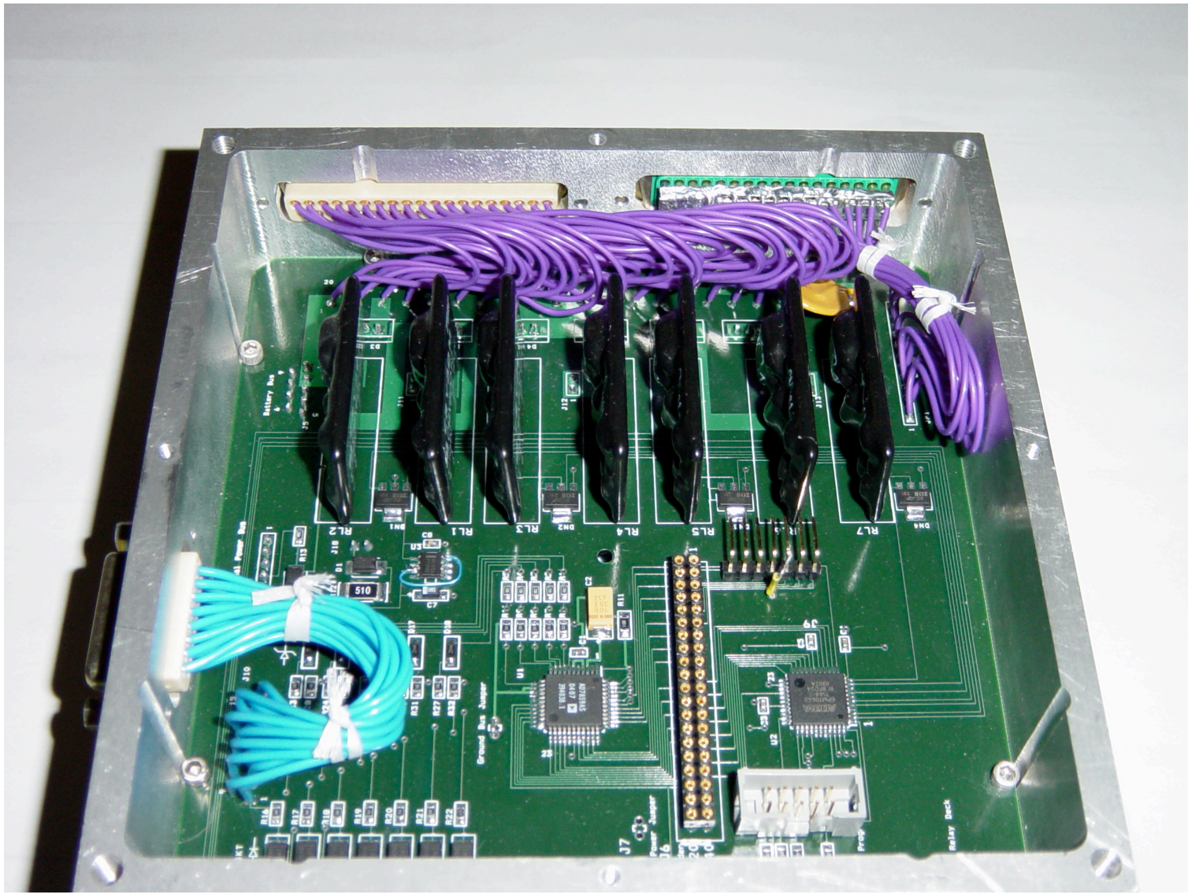
Program Benefits

- Reduces the landline requirements.
- Allows power system to be tested prior to installation in the payload.
- Incorporates bus monitoring and provides analog and RS232 outputs.
- Simplifies payload wiring.

Status

- Electrical design completed, first article board has been populated.
- Electrical qualification testing has been started.
- Test article will be flown on 12.063 Hickman Technology

Power in a Box



Command Uplink Receiver

Issues

- Aydin Vector model RCC103 receivers have been used repeatedly since 1993.
- Aydin Vector receivers have fixed IF and video bandwidths.

Solution

- PSL has developed a WFF93 footprint Command Uplink Receiver.

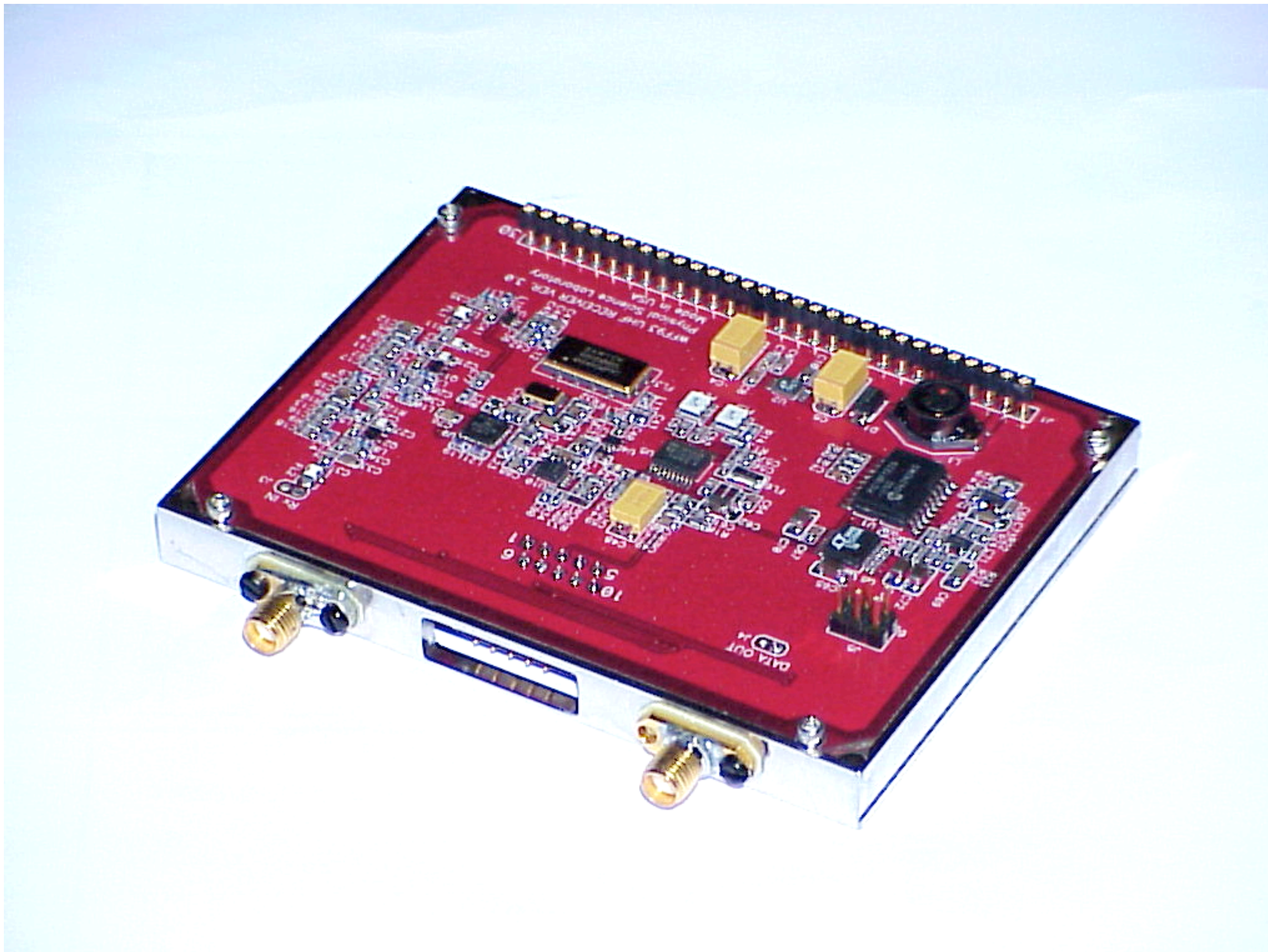
Program Benefits

- These new receivers will allow replacement of the AV hardware.
- New receivers will simplify Instrumentation System wiring and allow for a more compact payload mechanical layout.

Status

- Electrical design completed.
- First article board populated.
- Electrical qualification testing in-progress. Environmental qualification testing to be performed in July.
- Plans to incorporate new receiver on 12.063 Hickman Technology mission and/or as a non-mission critical piggyback on payloads being flown at WSMR.

Command Uplink Receiver



Strain Gauge Signal Conditioning

Issues

- Very limited capability to effectively signal condition strain gauges.

Solution

- Recent development of a programmable gain and offset operational amplifier allows circuit board fabrication, testing and stocking.
- Once mission requirements have been determined the circuit can be programmed for the appropriate gain and offset via external connector.

Program Benefits

- The new programmable gain and offset amplifier can be tested prior to “burning the fusible links” allowing much greater flexibility in strain gauge sensor offsetting and amplification.
- The gain and offset are set without having to modify or change components on the PC board.

Status

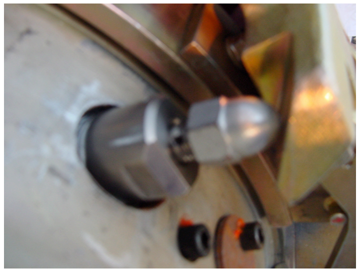
- Electrical circuit design has been completed.
- The PC board has been designed and procured and the first article board populated and tested.
- A 4 circuit version is being flown in the upcoming 12.060 Hickman mission.

Mechanical Engineering

Giovanni Rosanova

Mechanical Engineering
Terrier Clamp Release RTF

- 12.061 AIB determined that pin material not adequate to open clamp for entire range of possible clamp force values. Also discovered that Holex 6101 pyrotechnic devices have inconsistent energy output.
- Using experience gained by Orbital Sciences Launch Systems Group to reanalyze system for our use.
- Considering changes to assembly procedure to ensure more repeatable clamp release force.
- Will select new pin material to adequately open under new clamp force range.
- Will select new pyrotechnics with more consistent output energy
- Will measure flight vibration environment in vicinity of clamp release electronics to verify current testing loads.
- Will conduct technical reviews and testing to verify changes mentioned above.
- Target 41.055 Player as RTF mission (December, 2005)



Mechanical Engineering
Terrier Fin Evolution

- Since the 41.046 failure in Kwajalein, Terrier 4.8 sq-ft fin design has been further scrutinized.
- Thicker backing plate installed at fin cant adjustment interface.
- Introduced 4.6 sq-ft fins for 12.062 Nike-Orion Mission (3-fin Nike). Also flew on 41.057 Heath (Terrier-Orion) in May.
- Will introduce 5.0 sq-ft fin for 12.060 Hickman (Terrier-ASAS) test flight in Late June.
- Load testing has been conducted for each variant to qualify for flight.
- Further design changes are being considered to improve capabilities of these fins; e.g., leading edge tip restraint ring, tail can interface restraint improvements, etc.

Guidance, Navigation & Control

Walt Costello

GNC Activities

- New Hire – Neil Shoemaker
  - Software Engineer w/ Celestial ACS experience
- Boost Guidance Systems
  - Current Situation
  - Future Situation
- GPS Velocity Vector Input to NIACS
  - Earle 36.218
- Celestial ACS Design
  - Celestial Requirements
  - Pneumatics and Valve Drivers
  - Algorithms
  - Testing
- Poker Flat Campaign, 2007

Boost Guidance Systems

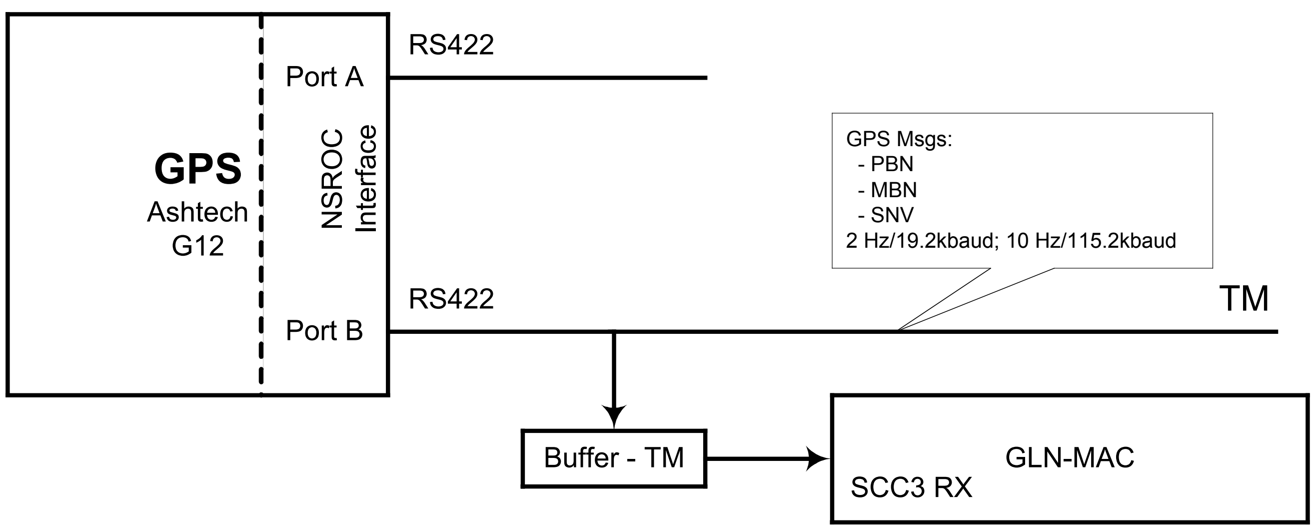
- Current Situation
  - 2 refurbished MIDAS gyros left for S-19A system
    - Also have 2 operational but unrefurbished MIDAS
  - 3 S-19D w/DMARS
    - NASA to obtain 2 additional DMARS excess at Sandia
    - Approx 4 month refurbishment cycle for S-19D
    - Scientific missions covered thru Jun 06
  - Feldman TM failure at EOG never explained –
    - Probable uncommanded S-19D OFF signal
      - Or coincidental failure
    - Altitude switch prevented failure prior to End of Guidance
    - SAAB fix week of 13 June 2005 to improve testability and visibility of S-19D OFF function
      - Additional telemetry discretes
      - Altitude switch testability
      - Raise altitude switch from 30 to 50K

Boost Guidance Systems

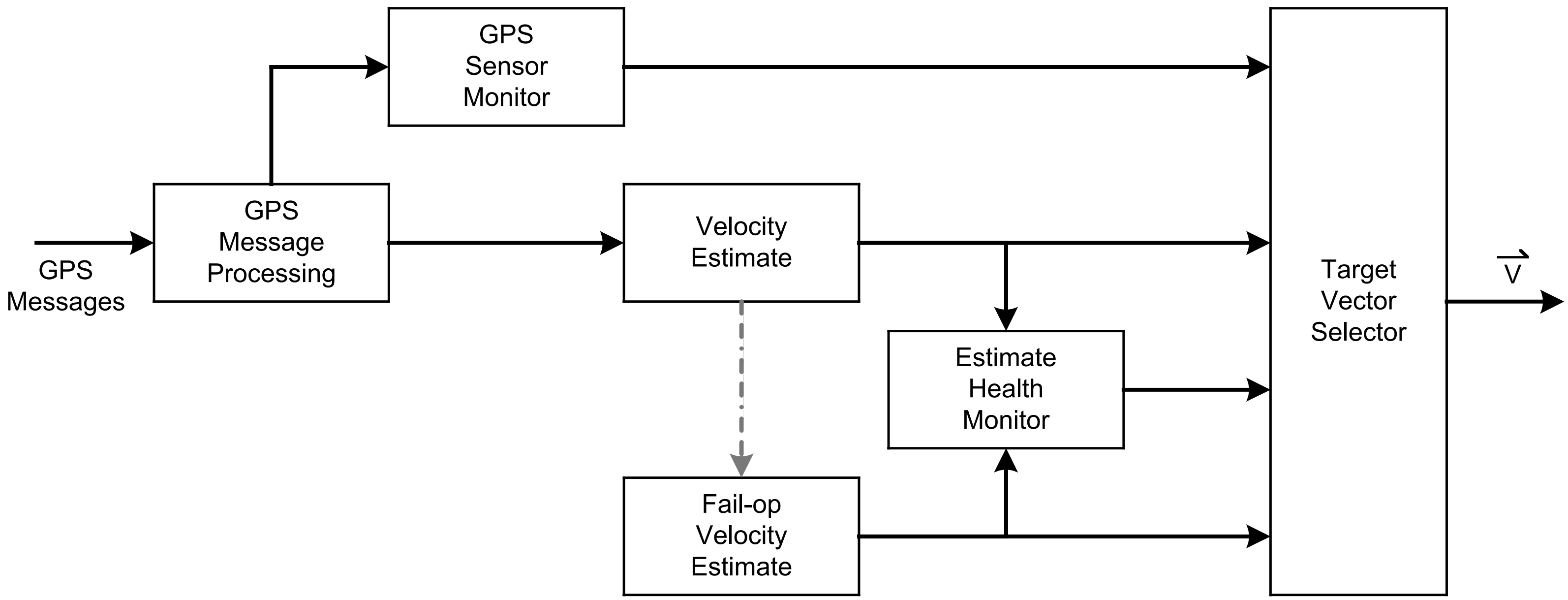
- Future Situation
  - 4 S-19L systems are being procured
    - Strap-down LN-200 is adequate for Rail Attitude Hold only
    - More reliable without gimbal
    - Reimbursable missions made procurement possible
  - S-19G design available
    - Tap off NIACS/Celestial GLN-MAC or self contained
    - Can be IIP-capable like DS-19
  - Both designs:
    - Build on existing DS-19 design & software
    - Replace DMARS
    - Incorporate SAAB Guidance Processor Unit
      - Accepts raw LN-200 data

GPS Integration – Earle 36.218

- Connect to GLN-MAC SCC3 @ 115.2 kbaud.
- PBN message has measurement information (state vector).
- MBN messages have information to access “health”.

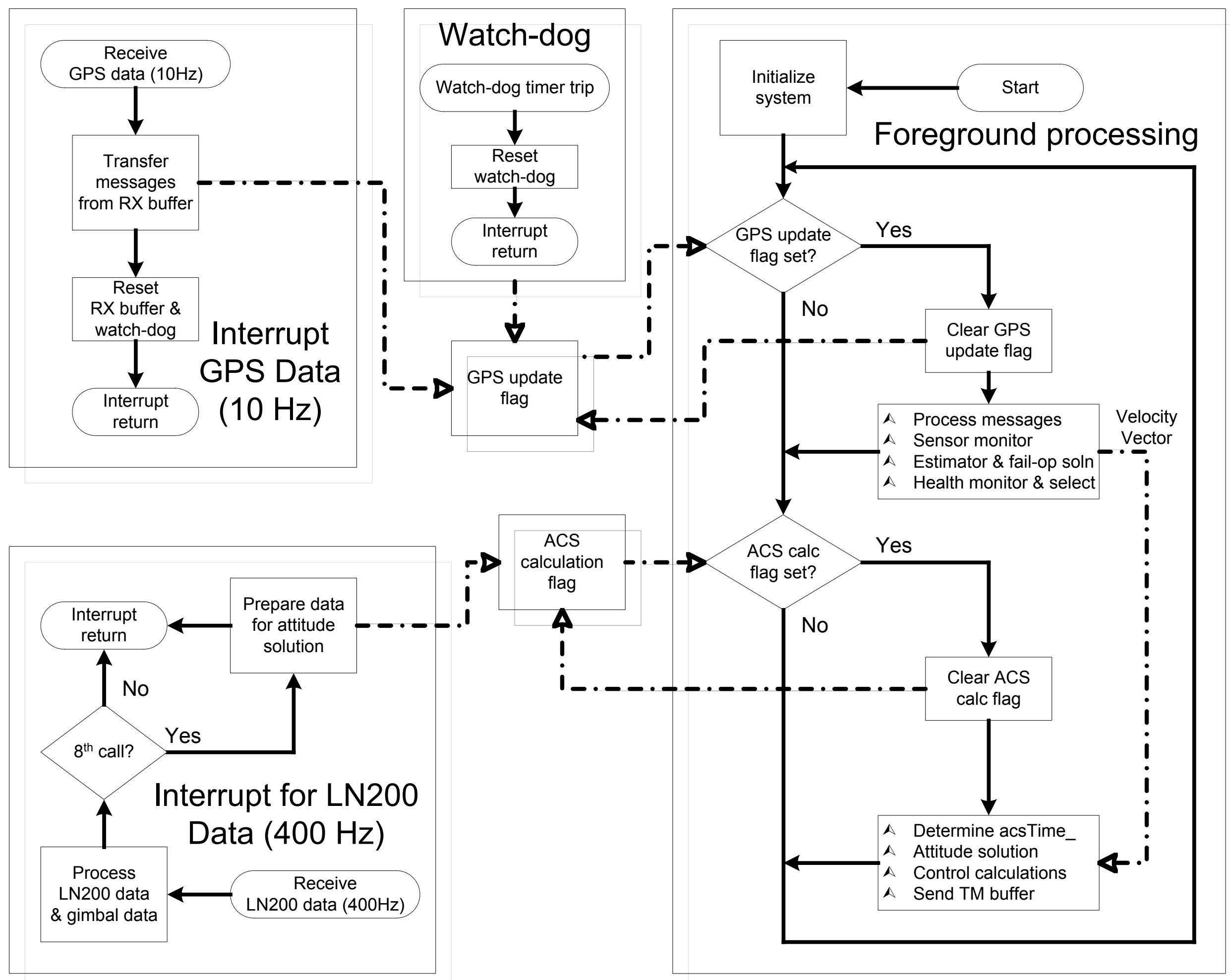


Velocity Vector Calculation Architecture



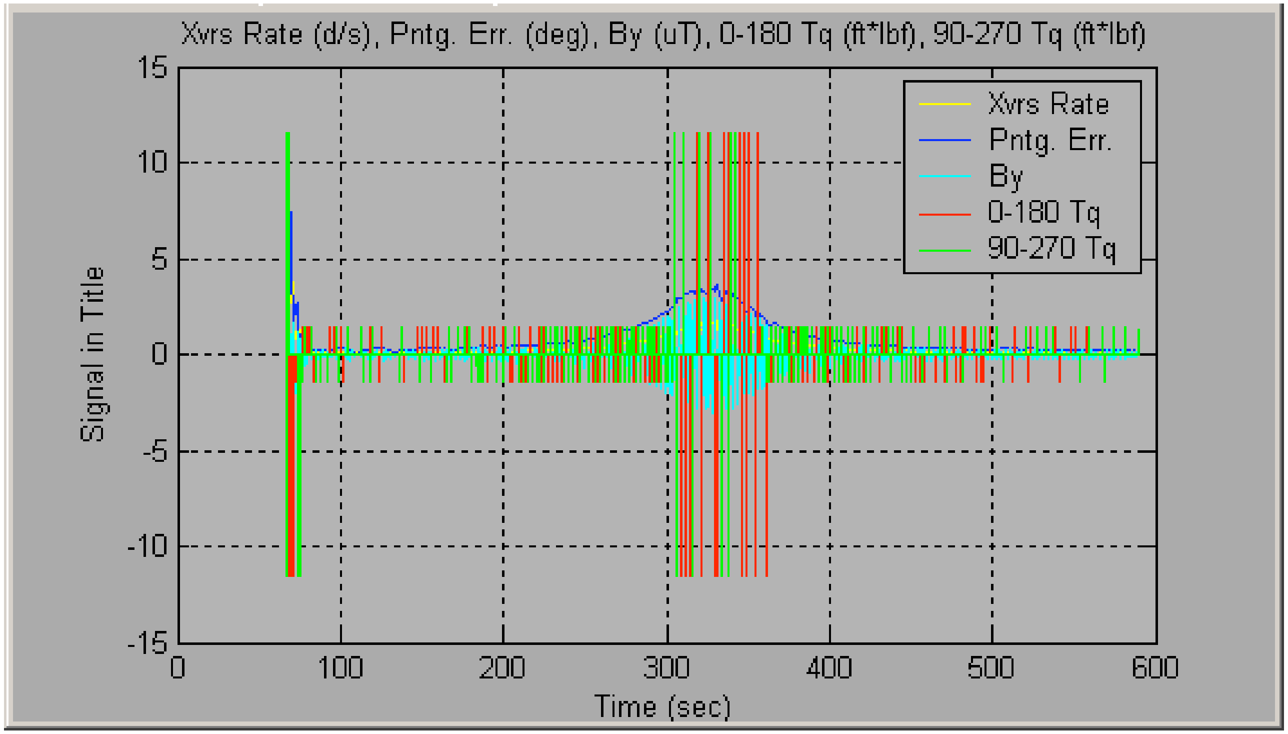
NIACS Software Flow of Execution

- Extended from base NIACS software system.



Velocity Vector – Continuous Fine Targeting

- Typical error < 1.0°.
- Gas consumption < 50% (early analysis).



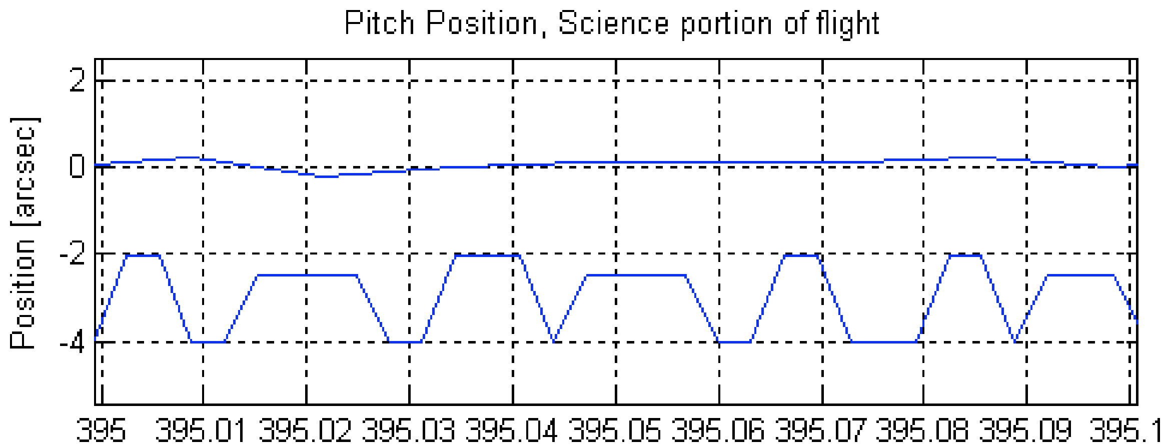
Celestial ACS Requirements

- Requirements for the Celestial ACS are driven by the requirements for the Cruddace 36.207 mission which has a very severe rate/jitter requirement of 1.0 arcsec/sec for comprehensive success and 2.0 arcsec/sec for minimum success.
- With careful preparation, this requirement was met on the previous Cruddace mission with the Mk VI-D system which was previously in use. The MK VI-D system interfaced with the SPS tri-level pneumatic system which has been retained as the pneumatic component of the new NSROC Celestial ACS.
- There is no such thing as a “Standard” Celestial mission. The system must be tailored to each individual mission. However, the system is capable of meeting requirements for all currently scheduled missions.

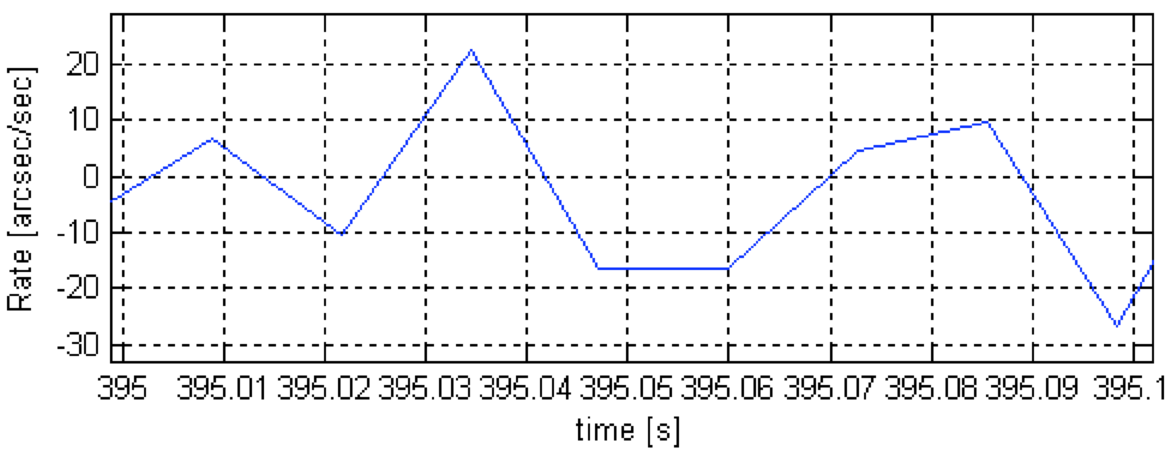
Other Scheduled Celestial Missions

- 36.220 McCandliss   Jan 2006
  - Target position within +/- 5 arc-min
  - Good alignment required
  - ACS provide “on-target” signal
- 36.224 Cash   May 2006
  - Initial acquisition within +/- 5 arc-min
  - Final acquisition within +/- 15 arc-sec (with uplink)
  - Less than 1 arc-sec/sec drift rate
- 36.225 Chakrabarti   Jan 2007
  - Must acquire within 1 arc-sec
  - Very precise control based on science provided “perfect” error signal
- 36.226 Bock May 2007
  - 3 arc-sec max error in 20 seconds
  - Side looking ST-5000 (Maybe two)

Cruddace 36.195 Performance

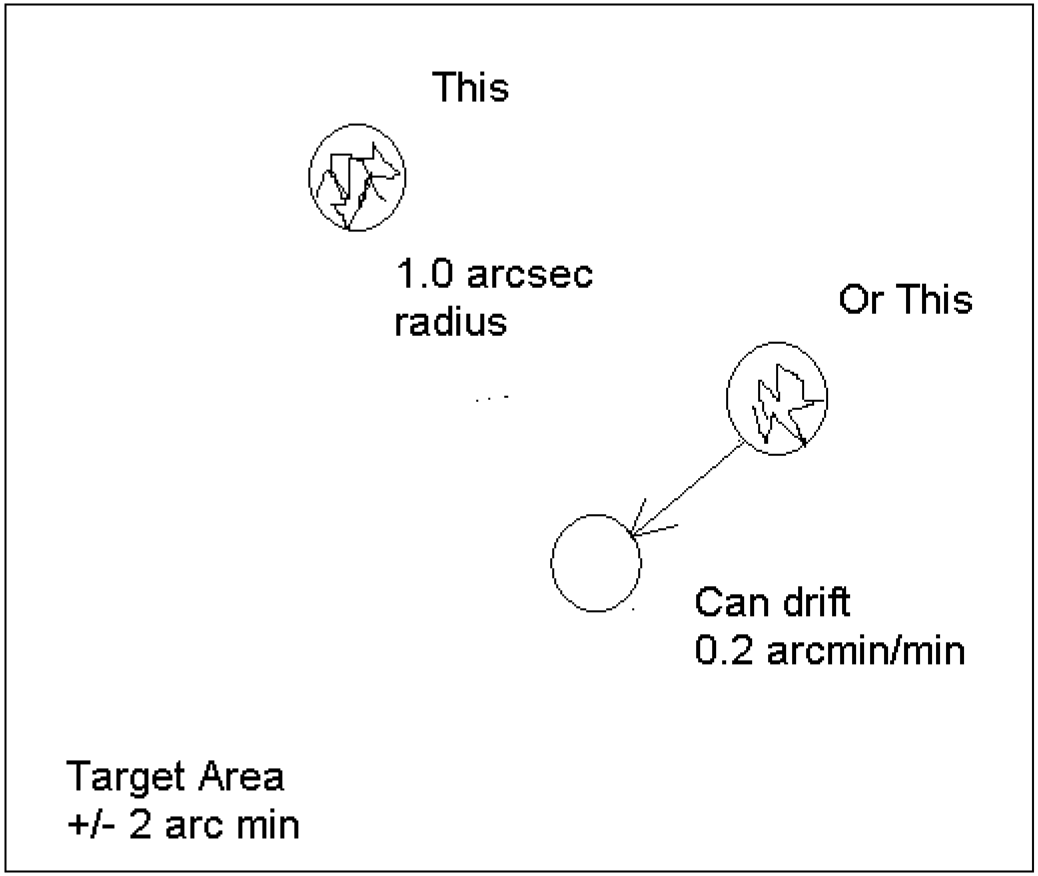


Low Average rates



High Instantaneous Rates

What Does Cruddace Spec Mean?

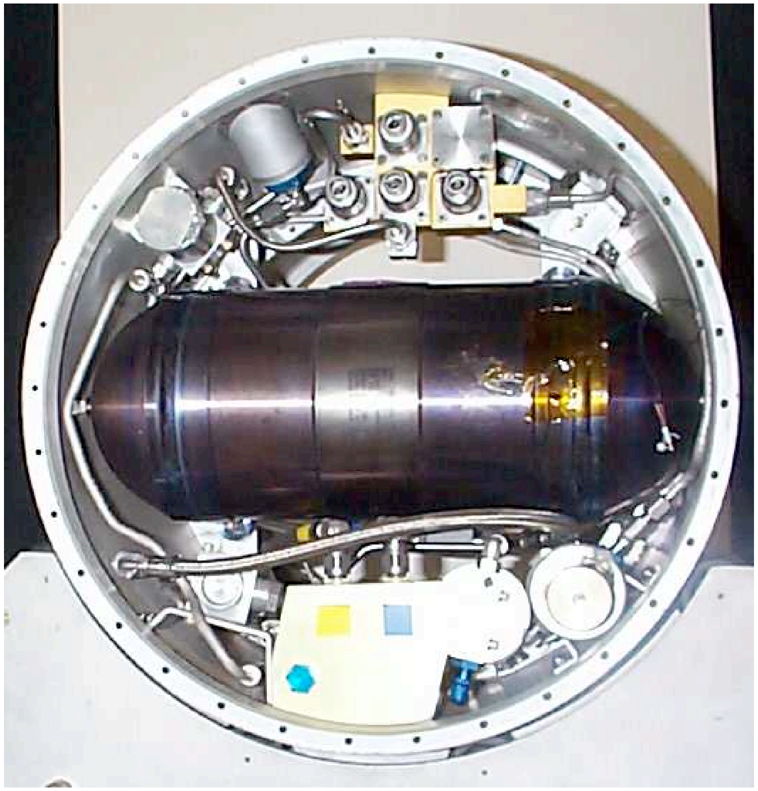


Celestial ACS Challenges

- Designing & building valve driver capable of very fine thrust control
- Integrating ST-5000 into NIACS tracking loop
- Designing & coding state space observer/controller to overcome measurement nose and achieve required performance
- Creating air bearing test environment capable of simulating star field and measuring fine pointing performance
- Designing processes and writing procedures to minimize risk and ensure success
- Accomplishing the above efficiently and rapidly

CACS PNEUMATICS (BASIC SPS)

SPS



(MK-6 CONFIG SHOWN HERE)

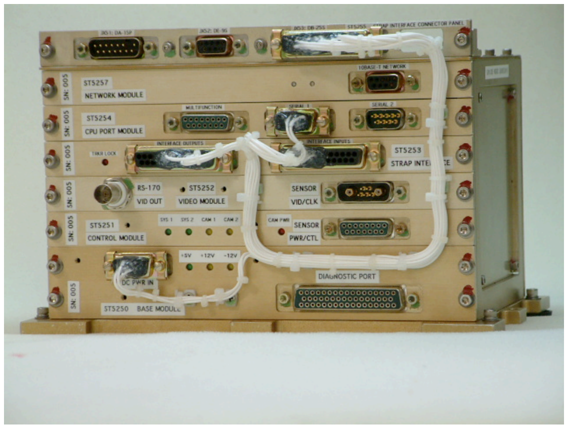
- 395 CUBIC INCH TITANIUM PRESSURE VESSEL
- TOTAL OF 4 REGULATORS
- TOTAL OF 4 TRANSFER VALVES
- 2 ROLL CONTROL VALVES (CW & CCW)
- HIGH FLOW SPIN-UP VALVE
- 2 COMPLEX MULTI LEVEL MANIFOLDS
- FLEX HOSES FOR REMOTE NOZZLE FEEDS
- CHECK VALVES, FILL VALVE, RELIEF VALVE
- 5 TRANSDUCERS
- BI-LEVEL P&Y CONTROL
  - 2 REGULATORS
  - 2 TRANSFER VALVES
- TRI-LEVEL ROLL CONTROL
  - 2 REGULATORS
  - 2 TRANSFER VALVES

Valve Driver Board
Supported Modes

Roll	Pitch	Yaw
Coarse	Coarse	Coarse
Intermediate	Intermediate	Intermediate
Fine	Fine	Fine
Differential Fine	Differential Int	Differential Int
Partial Pulse Fine	Partial Pulse Int	Partial Pulse Int
Bleed	Differential Fine	Differential Fine
Spin-up*	Partial Pulse Fine	Partial Pulse Fine
	Bleed	Bleed
	Vent	Vent

*All Modes are Bi-Directional, except Spin-up

ST5000 Star Tracker

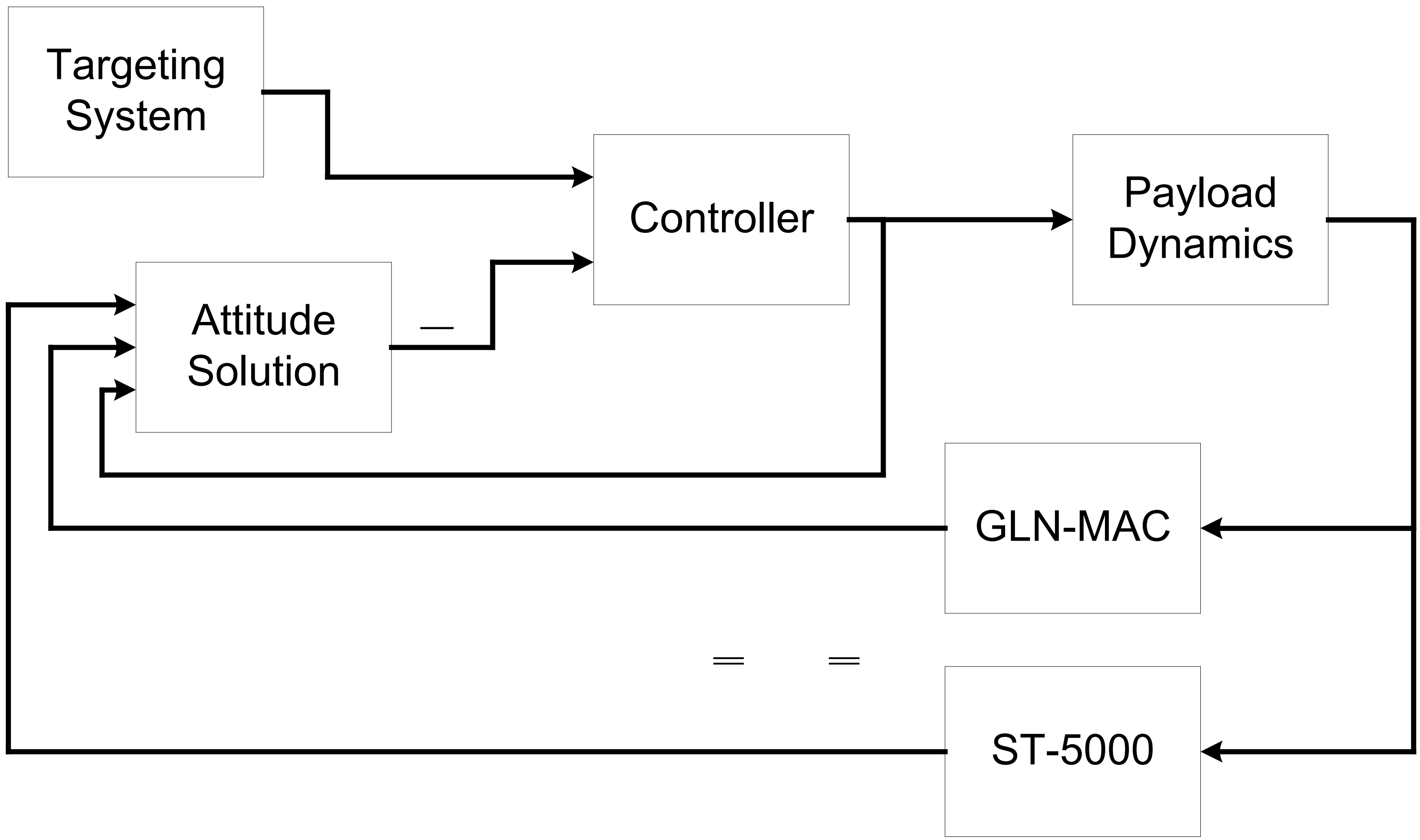


ELECTRONIC CONTROLLER

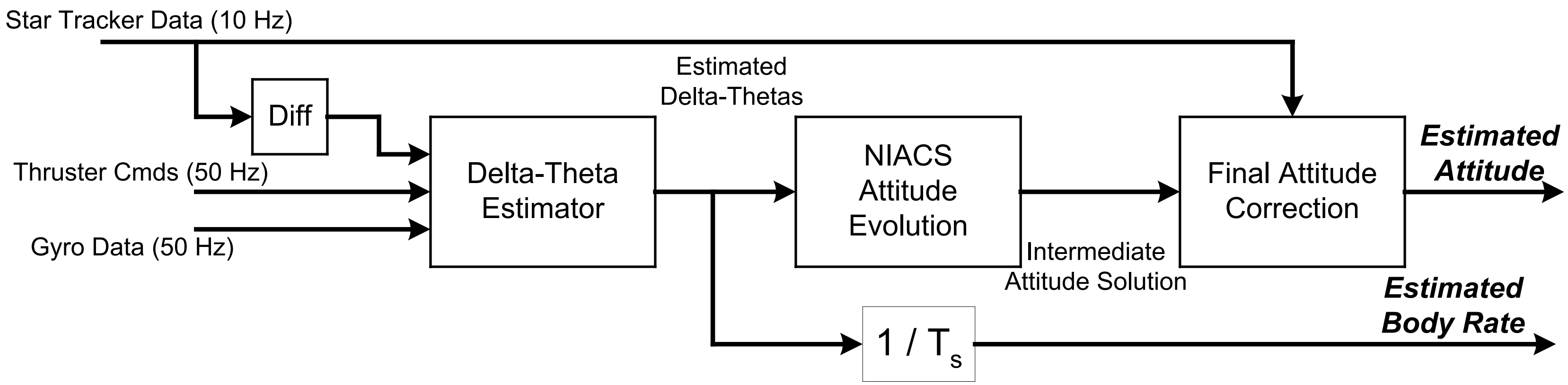
TRACKER CAMERA

- Camera can be mounted as far at 12 feet
  from the electronics controller.
- Tracker camera weighs 3.7 pounds.
- Electronics Controller box weighs 6.4 pounds.

General Control Approach

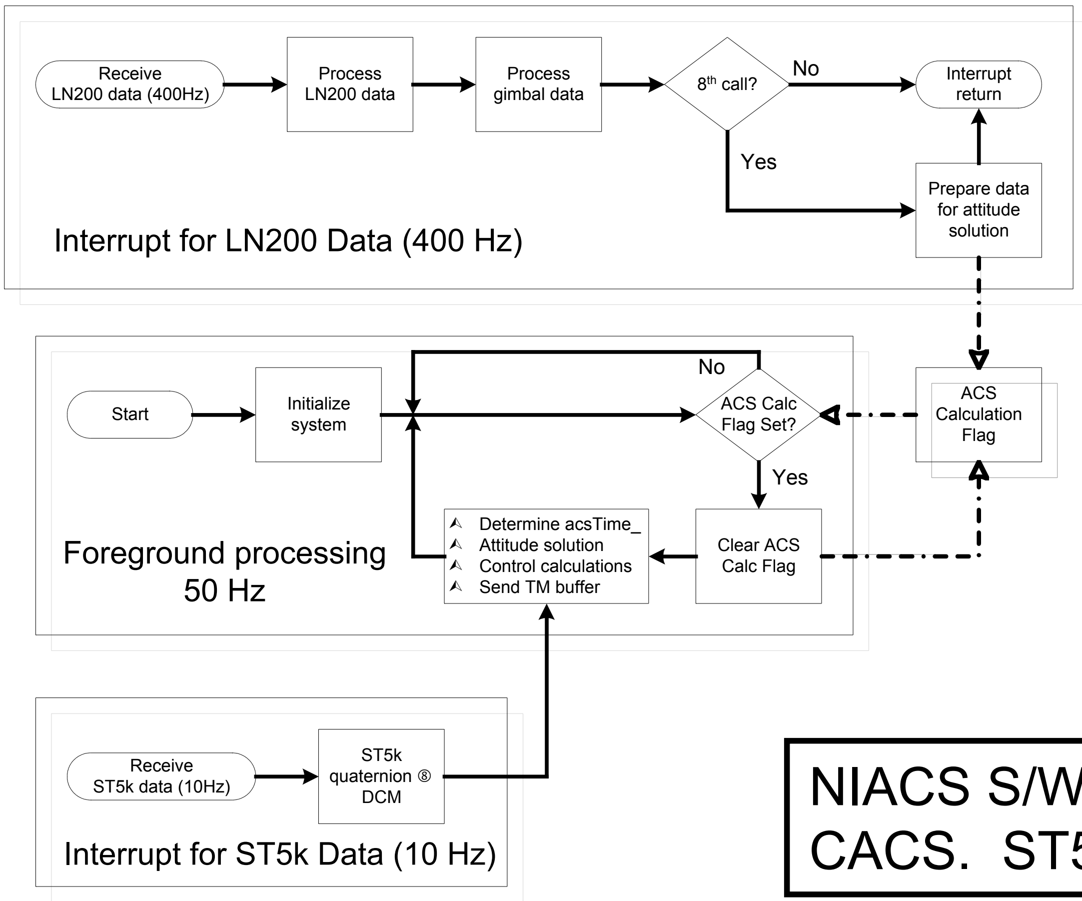


Body Rates & Delta Thetas



- The body rates come directly from the estimated delta thetas (or from the gyro delta thetas during coarse maneuvers).
- Subsequent slides address body rates from the estimated delta thetas as well as the raw sensor measurements.

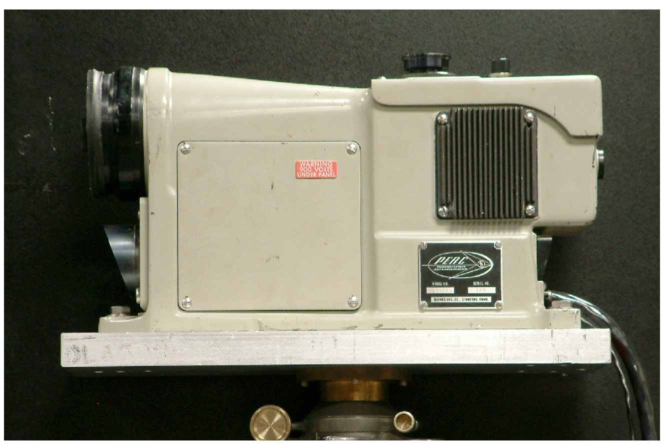
Flow of Execution

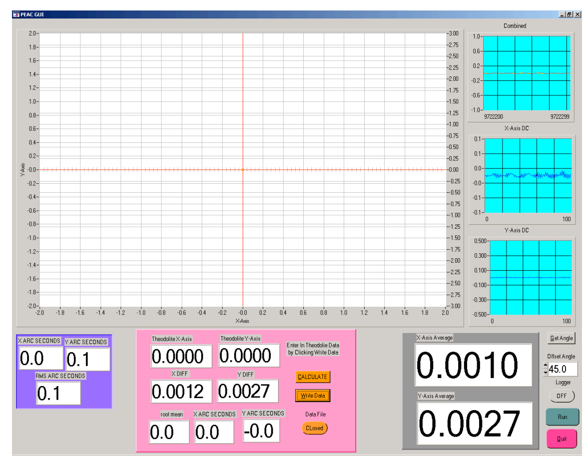


NIACS S/W structure extended for CACS. ST5k data is asynchronous.

PEAC

- Photo-Electric Auto Collimator
  - Measures Angular Offset, FOV +/- 1 arc min
  - Needed to Verify Very Fine Pneumatics Performance
  - Calibration In Progress, Instrument Function Marginal
  - Current Measurement Error +/- 2 arc sec, needs to measure 1 arc sec/sec jitter
  - New Measurement Device On Order



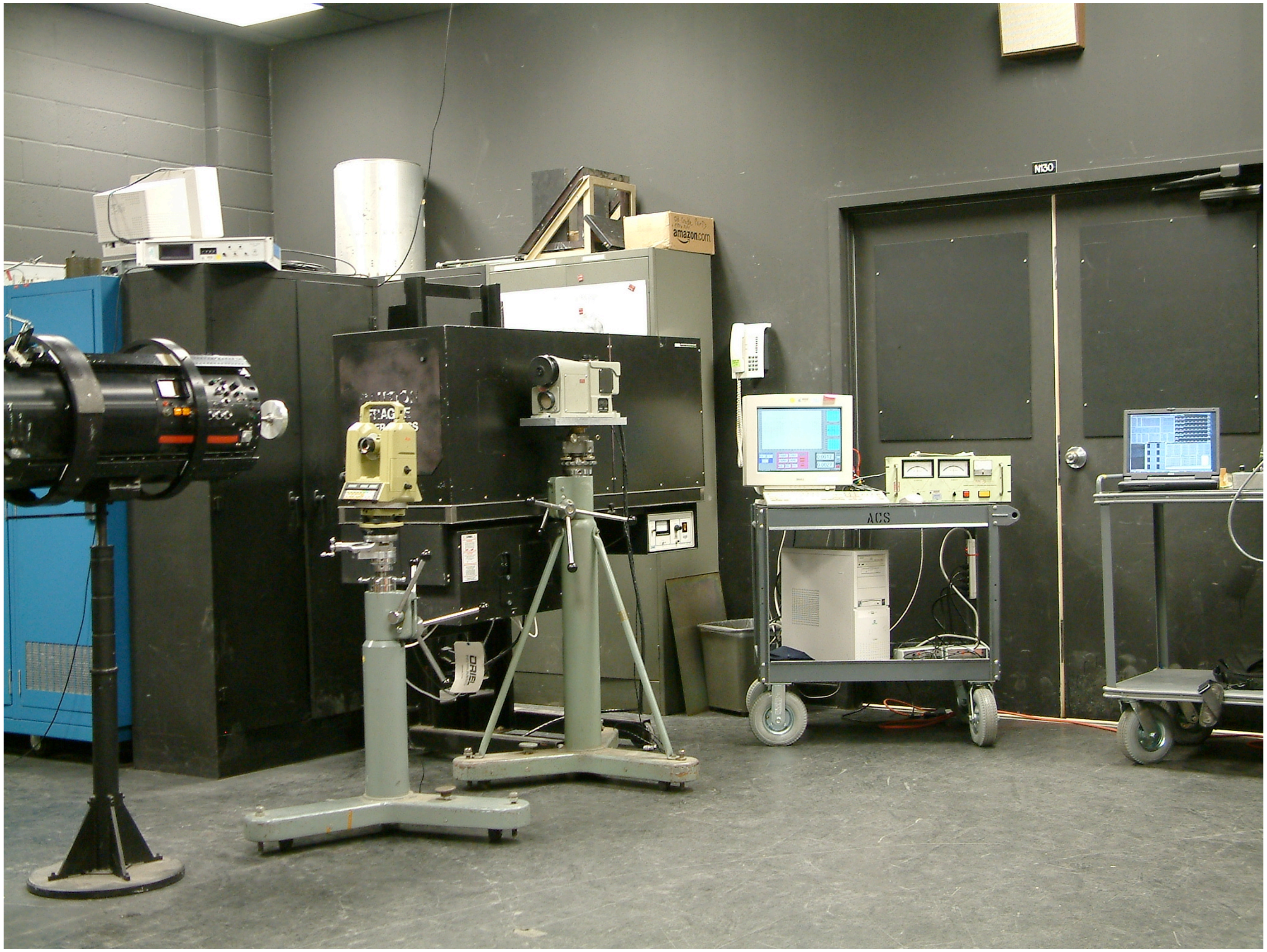


New “PEAC” – the LACkey

T100 Laser
Autocollimator

T100 and Support
Equipment

Air Bearing Test



Celestial Continuous Improvement Road Map

- Interface for experimenter error signals (Chakrabarti)
- Finer, quieter pneumatic valves (Chakrabarti)
- Interface for 2nd star tracker (Bock)
- GSE – replace S5/GATAR
- Valve driver diagnostics
- Simplify targeting and mission planning
- Speed up Lost in Space (second and subsequent)
- Mission independence of software
- Software in the loop (SWIL) simulation
- Hardware in the loop (HILTS) simulation

Poker Flat Campaign 2007

- Larsen –
  - 2 NMACS
  - Similar to Joule
  - Also 2 chemical rockets
- Lessard –
  - NMACS or NIACS being considered
  - Complex sub-payloads
- LaBelle –
  - NMACS
  - Straightforward mission
- Craven –
  - NIACS
  - Trajectory modification similar to Conde
  - Also three instrumented chemical rockets

Thank You For Your Support

- NSROC ACS stands ready to support experimenters worldwide.
- Questions?
- Comments?
- Observations?

Conclusions

- NSROC Is Committed to Continuing the Mission and Program Successes
- Satisfying the Code S PI Mission Requirements Is Still NSROC's Primary Goal
- NSROC Is Committed in Expanding the Technical Innovations While
  - Maintaining a Cost Effective Environment
  - Meeting the Success Requirements of the PIs
  - Making Effective Use of the In-House Talent and Experience
- NSROC's Receipt of the SRWG Findings Is Important for Future Growth Planning